Preliminary Investigation

Caltrans Division of Research, Innovation and System Information

GIS Standards and Technology Implementation

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The Caltrans Division of Research, Innovation and System Information (DRISI) receives and evaluates numerous research problem statements for funding every year. DRISI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field. The contents of this document reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the California Department of Transportation (Caltrans), the State of California, or the Federal Highway Administration. This document does not constitute a standard, specification, or regulation. No part of this publication should be construed as an endorsement for a commercial product, manufacturer, contractor, or consultant. Any trade names or photos of commercial products appearing in this publication are for clarity only.

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Executive Summary

Background

The ability to make data-driven decisions for transportation system management has long been a desire [1,2], and more recently a requirement with the passage of Moving Ahead for Progress in the 21st Century (MAP-21) and the Fixing America's Surface Transportation Act (FAST Act). MAP-21, FAST Act, and Transportation Asset Management (TAM) initiatives require that data be accessible and interoperable in order to report on how well a Department of Transportation (DOT) is managing assets and how well the transportation system is performing. In order to have interoperable data, data and technology standards are required. These standards need to be understood and supported by the functional areas that create and maintain the data as well as the Information Technology (IT) staff members that keep the systems operating in a sustainable manner.

The majority of transportation data is geospatial in nature, and as such, this investigation focuses on the standards and systems that support Geographic Information Systems (GIS). Caltrans is attempting to standardize GIS data and technology across the Department in order to improve interoperability and sustainability of the various data and systems that present and interact with geospatial data in a manner consistent with National Spatial Data Infrastructure (NSDI) and Federal Geographic Data Committee (FGDC) recommendations.

The need for improving GIS operations at Caltrans has been identified in numerous studies and documents over the last 15 years. Two recent documents include Every Day Counts 2: Geospatial Data Collaboration and Geospatial Strategic Direction. These Caltrans documents identify both the opportunity and necessity for Caltrans to document and adopt data and technology standards surrounding geospatial data and services.

This preliminary investigation (PI) was conducted with DOTs and California-based local transportation agencies to capture best practices and lessons learned on adopting and implementing GIS data and technology standards and to obtain related documentation. This PI provides the following:

- A literature review of GIS data standards, policies, and best practices in place from a selection of DOTs and California-based local transportation agencies.
- GIS survey results from selected DOTs and California-based local transportation agencies for their GIS governance, policies, data standards, and best practices.

Summary of Findings

A GIS containing managed spatial data allows a user to display, analyze, and manipulate the data for a variety of purposes. Geospatial data analysis can be used as a decision support tool for pinpointing “hot spots,” performing root cause analysis, allocating staff and resources, measuring performance, and many other activities which support a DOT’s mission. For example, a breakthrough in the Takata airbag failure investigation by the National Highway Traffic Safety Administration (NHTSA) came when failure locations and environmental conditions were plotted using GIS software. The resulting map showed a clear correlation between failures and areas of high heat and humidity [3]. The Federal Highway Administration (FHWA) has performed extensive research into GIS with the cooperation of state DOTs. FHWA

has hosted DOT peer-to-peer exchange meetings. The FHWA GIS website[1] has a long list of reports detailing many state DOTs' GIS efforts. Example include:

- GIS Capability Maturity Model Peer Exchange
- All Road Network of Linear Referenced Data (ARNOLD) Peer Exchange
- Uses of Geospatial Applications for Transportation Performance Management Peer Exchange
- Making a Business Case for Geographic Information System (GIS) Technologies: Case Studies of Select Transportation Agencies
- Business Models for Implementing Geospatial Technologies in Transportation Decision-Making: Phase Two
- Geospatial Tools for Data Sharing: Case Studies of Select Transportation Agencies
- The Interoperability of Computer-Aided Design (CAD) and Geographic Information Systems (GIS) in Transportation: Case Studies of Select Transportation Agencies
- Best Practices in Geographic Information Systems-Based Transportation Asset Management

The FHWA website[2] has links to many other GIS resources and tools useful for DOT GIS services. FHWA's Geospatial Data Collaboration (GDC) is a new initiative for geospatial data sharing. The GDC initiative encourages state DOTs and other agencies to use geospatial tools to streamline transportation decision-making and improve data sharing within an agency and with external stakeholders.

GIS Strategic Plan

The purpose of a GIS Strategic Plan is to examine the current use of GIS at a DOT and set goals to optimize GIS's potential. A Strategic Plan is accompanied by an Implementation Plan, which provides timelines, tasks, and resource requirements [3]. The GIS Strategic Plan for the U.S. Department of Transportation, Version 1.0 2016-2019,[3] provides detailed guidelines and an example of a GIS strategic plan, including GIS governance and an implementation plan. Caltrans has created a Geospatial Strategic Direction.

Google searches yielded GIS Strategic Plans from other state DOTs and local agencies:

- Iowa DOT's GIS Strategic Plan[4]
- Data Business Plan – Minnesota (Mn) DOT,[5] containing MnDOT's data governance policy and framework as well as strategic planning for GIS
- Florida DOT's (FDOT) Enterprise GIS presentation[6]
- Kansas DOT's GIS Strategic Plan[7]
- New Hampshire's GIS Strategic Plan[8]
- Ohio DOT's Enterprise GIS Strategic Planning presentation[9]

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[1] https://www.gis.fhwa.dot.gov/reports.asp
[2] https://www.gis.fhwa.dot.gov/default.asp
[3] https://www.transportation.gov/sites/dot.gov/files/.../GISStrategicPlan_0831_final.pdf
[4] www.intrans.iastate.edu/reports/gis_strategic_plan.pdf
[5] www.dot.state.mn.us/tda/databusinessplan.docx
[6] http://www.fdot.gov/design/Training/DesignExpo/2014/presentations/JaredCausseauxFDOT-GIS.pdf
[7] https://www.ksdot.org/Assets/wwwksdotorg/bureaus/burTransPlan/transP2/kdotfinal.pdf
[8] https://www.fgdc.gov/grants/2006CAP/relateddocs/119-06-3-NH-StrategicPlan.pdf
[9] http://www.gis-t.org/files/nxPBf.pdf

- Oregon DOT's GIS Strategic Plan[10]
- Oregon Geographic Council's Strategic Plan for Geographic Information Management (2010)[11]
- West Virginia's GIS Strategic Plan[12]
- Virginia's GIS Strategic Plan 2010-2015[13]
- California's GIS Strategic Plan Phase 2: Regional Participation[14]
- District of Columbia's GIS Strategic Plan[15]
- City of Guelph, Canada, GIS Strategic Plan[16]
- City of Alexandria, VA, GIS Strategic Plan[17]

GIS Governance and Policy

GIS strategic plans often contain GIS governance and policy details for their organizations. In some cases, the GIS governance and data policy is covered under the general data governance and data policy of the state-level IT or Chief Information Officer (CIO). GIS strategic plans and GIS governance and data policies differ due to differences in organizational structure. Generally, a GIS governance and data policy addresses the following:

- Mission and goals
- Success measures
- Purpose and structure
- Governance structure
- Role, responsibilities, and accountabilities
- Adoption of rules and regulations
- System completeness and accuracy
- Proprietary rights
- Compliance with Open Records Act
- Posting of rules and regulations
- Funding and resources required

Google searches yielded several GIS governance and data policies from several state DOTs and local agencies:

- Caltrans Transportation System Data Business Plan RFO# TSI DPR-0003,[18] published in September 2011, which provides recommendations on Caltrans data governance

[10] ftp://ftp.odot.state.or.us/techserv/geo-environmental/GIS/Committees/GIS_StrategicPlan_Draft/2006%20update%20draft%20GIS%20Strategic%20Plan%205-2000.doc

[11] http://www.oregon.gov/geo/OGIC%20Documents/2010FinalGISPlan_091510.pdf

[12] http://www.wvgs.wvnet.edu/www/giscoord/wvgis_data/wvgis_documents/WVGIS_Strategic_Plan11-01-2010.pdf

[13] https://www.vita.virginia.gov/uploadedFiles/VITA_Main_Public/ISP/VGIN_Board/2010/VGIN%202010-2015%20GIS%20Strategic%20Plan_Final.pdf

[14] http://www.sdrgc.org/Documents/Docs/docs_20150114/CA-StrategicPlan-P2.pdf

[15] https://octo.dc.gov/sites/default/files/dc/sites/octo/publication/attachments/DC_GIS_Strategic_Plan%202016_FINAL.pdf

[16] http://guelph.ca/wp-content/uploads/GIS_Stratigic_Plan.pdf

[17] https://www.alexandriava.gov/uploadedFiles/gis/info/GIS%20Strategic%20Plan%20Approved%20Final.pdf

[18] http://www.dot.ca.gov/hq/tsip/data_library/data_governance/CTS_DataBusinessPlan_8_29_11.pdf

- Colorado GIS Data Governance Plan[19]
- Iowa DOT Geospatial Governance and Guidelines[20]
- State of Oklahoma Data Governance Resource Index[21]
- The Oregon Geographic Information Council's website[22] provides its data-sharing policies, agreement, and legislation
- The San Diego Geographic Information Source (SanGIS) Policies and Procedures Manual[23] provides detailed documentation on how SanGIS enters, edits, and publishes data and provides information on SanGIS's purpose, roles, and responsibilities. SanGIS is a Joint Powers Authority (JPA) of the City of San Diego and the County of San Diego, and is responsible for maintaining a regional GIS.
- Wisconsin Geographic Information Technology (GIT) Governance State Model and Best Practices[24]
- Weld County, Colorado Charter Chapter 9 Article V GIS Governance[25]

GIS Best Practices

FHWA, NCHRP, state DOTs, and local agencies provide workflow and best practices documents which address various GIS issues from data collection to enterprise GIS implementation. The National Cooperative Highway Research Program (NCHRP) Report 800 Successful Practices in GIS-Based Asset Management [4] provides guidance for how state DOTs and other transportation agencies can enhance their asset-management capabilities through effective adoption of GIS technologies and information through pilot demonstrations and workshops on implementation of GIS-based TAM practices. FHWA's Best Practices in Geographic Information Systems-Based Transportation Asset Management[26] presents information on innovative approaches to using GIS for TAM, along with a literature review and interviews with several transportation organizations (Ohio DOT, Washington DOT, Oregon DOT, Colorado DOT, Michigan DOT, and the Department of Public Works in St. Johns County, Florida). The FHWA GIS report website[27] contains a large repository of useful GIS documents, including:

- GIS Capability Maturity Model Peer Exchange[28]
- Geospatial Tools for Data Sharing: Case Studies of Select Transportation Agencies[29]
- Geospatial Data Sharing Peer Exchange: Denver, Colorado[30]
- Geospatial Data Sharing Peer Exchange: Raleigh, North Carolina[31]

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19 https://docs.google.com/a/state.co.us/viewer?a=v&pid=sites&srcid=c3RhdGUuY28udXN8b2l0LXRlbXBsYXRlLWRldnxneDozMTZlNGFkMmM0NWExZWEx

20 https://www.arcgis.com/home/item.html?id=3615135ff8214af3bf85775a6862811b

21 https://www.ok.gov/cio/documents/DataGovernanceResources.pdf

22 http://www.oregon.gov/geo/Pages/ogic.aspx

23 http://www.sangis.org/docs/documents/Policies_and_Procedures_Manual.pdf

24 https://www.fgdc.gov/grants/2006CAP/relateddocs/PA_Profile.pdf

25 https://www.municode.com/library/co/weld_county/codes/charter_and_county_code?nodeId=CH9INSE_ARTVGIGO

26 https://www.gis.fhwa.dot.gov/documents/GIS_AssetMgmt.pdf

27 https://www.gis.fhwa.dot.gov/reports.asp

28 https://www.gis.fhwa.dot.gov/documents/Capability_Maturity_Model_Peer_Exchange.pdf

29 https://www.gis.fhwa.dot.gov/documents/GeoSpatialToolsForDataSharingCaseStudies.pdf

30 https://www.gis.fhwa.dot.gov/documents/GeoSpatialToolsForDataSharingPeerExchangeDenver.pdf

31 https://www.gis.fhwa.dot.gov/documents/GeoSpatialToolsForDataSharingPeerExchangeRaleigh.pdf

FHWA's GIS Screening Tools web page[32] gives examples of effective GIS screening tools that are used by state DOTs for integration of GIS data from various sources. The FHWA's GIS Operating Agreements web page[33] offers examples of data sharing agreements between local agencies and state DOTs.

State governments and DOTs have also posted their GIS-related best practices and workflow documents online, including:

- The Colorado Governor's Office of Information Technology (OIT) which serves executive branch agencies and by extension, the residents of Colorado. The GIS Data Coordination Summit organized by the Colorado OIT attracted more than 80 representatives of GIS programs at the state and county levels in Colorado. The OIT website[34] provides video and Colorado 2015 GIS Data Coordination Summit presentation slides[35] to better understand OIT GIS data implementation in Colorado.
- The State of Minnesota's A Program for Transformed GIS in the State of Minnesota: Program Design & Implementation Plan[36]
- North Carolina DOT's Geospatial Standards and Practices website[37]
- Wyoming DOT Geographic Information Systems Standards[38]
- Utah DOT Recommended Protocol and Standards for Utility Data Submittals UT-11.07_Protocol for Utility Data Submittals Final Report Feb 2012[39]
- Massachusetts DOT Road Inventory Dictionary[40] provides details of their GIS road inventory naming and attributes
- Kentucky Transportation Cabinet Standards for Road Data Collection & Maintenance Using Global Positioning System Techniques[41]
- SHRP2 2015-11-18 Geospatial Data Collaboration Tools for Data Sharing Presentation[42] summarized several state DOTs' current GIS developments
- Washington DOT Roadside Features Inventory Program[43]
- The Oregon Geographic Information Council (OGIC), comprised of representatives from 22 Oregon state agencies, four local governments, and two federal agencies, shared their GIS documents and presentation files on their website.[44] Relevant documents and presentations are:
    - Data Sharing Resolution
    - OGIC Letter to AG on Data Sharing
    - Proposed Data Sharing Legislation - April, 2014
    - Framework Data License Agreement

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32 https://www.gis.fhwa.dot.gov/gdc_tools.asp

33 https://www.gis.fhwa.dot.gov/gdc_agreements.asp

34 http://www.oit.state.co.us/gis

35 https://docs.google.com/a/state.co.us/viewer?a=v&pid=sites&srcid=c3RhdGUuY28udXN8b2l0LXRlbXBsYXRlLWRldnxneDo3MWNhNzg4YTVjOTZkY2I3

36 http://www.gis.state.mn.us/committee/MSDI/dte/ProgramDesign_FinalFeb09_V21.pdf

37 https://connect.ncdot.gov/resources/gis/Pages/GIS-Standards.aspx

38 http://gis.wyoroad.info/docs/standards.html

39 https://www.udot.utah.gov/main/uconowner.gf?n=11036730520698057

40 https://www.massdot.state.ma.us/Portals/17/docs/RoadInventory/RoadInvDictionary.pdf

41 http://transportation.ky.gov/Planning/Documents/GPSMaintenanceStandardsall_rev.pdf

42 www.gis-t.org/uploads/2015-5.2.1.pdf

43 http://www.ce.siue.edu/faculty/hzhou/Highway%20Inventory%20Refereces%5CRFIP_Morin.pdf

44 http://www.oregon.gov/geo/Pages/ogic.aspx

- Oregon Geospatial Coordination Model (pdf)
- GIS and Confidentiality (pdf)
- Resolution in Support of Aerial Imagery for the Nation (pdf)
- OGIC Disclaimer Policy (pdf)
- Authorization for OGIC: Executive Order No. EO-00-02 (pdf)
- GIS Software Standard OAR
- GIS Software Standard FAQ
- Leveraging Geospatial Clearinghouse (pdf)
- Integrated Information Systems (ppt)
- Script for GIS Utility Presentation (pdf)
- GIS Utility Presentation to the HIMTC – 2/15/05 (pdf)

National GIS and Peer-to-Peer Support Meetings

Many state DOT GIS practitioners have presented their latest developments and practices to improve their DOT GIS IT infrastructure and data in national and peer-to-peer exchange GIS meetings. These presentations are often posted on the organizers' websites. FHWA's GIS-Related Organizations website[45] lists the major organizations that host regular GIS meetings:

- The American Association of State Highway and Transportation Officials' (AASHTO) Center for Environmental Excellence – GIS Section developed the Center for Environmental Excellence (CEE) to serve as a resource for transportation professionals seeking technical assistance, training, and information exchange. The GIS section of the CEE provides an overview of GIS technology and its use as a tool for analyzing environmental issues in transportation. The GIS for Transportation (GIS-T) Symposium, annually hosted by AASHTO, offers proceedings and summaries of past symposiums and provides extensive contact information on their website.[46]
- National Consortium on Remote Sensing in Transportation (NCRST), a consortium of American universities devoted to consultation, research, and outreach for advanced technology and infrastructure development, hosts regular meetings and posts meeting presentations on their website.[47]
- National States Geographic Information Council (NSGIC) promotes the efficient development and management of location-based information resources, and advocates for innovative and strategic use of these assets to advance the interests of states, tribes, regions, local governments, and the nation. NSGIC organizes meetings[48] twice a year on GIS hot topics and provides profiles of state activities.
- Open GIS Consortium (OGC) is an international not-for-profit organization committed to making quality open standards for the global geospatial community. These standards are made through a consensus process, and are freely available for anyone to use in order to improve sharing of the world's geospatial data. OGC also host worldwide events addressing issues related to GIS standards.
- University Consortium for Geographic Information Science (UCGIS) is a non-profit organization that creates and supports communities of practice for GIS research, education, and policy endeavors in higher education and with allied institutions. UCGIS is professional hub for the academic GIS community in the United States and hosts a UCGIS symposium every year.

[45] https://www.gis.fhwa.dot.gov/gisOrgs.asp
[46] http://www.gis-t.org/
[47] http://ncrst.digitalgeographic.com/meetings/
[48] http://www.nsgic.org/meetings-programs

- Urban and Regional Information Systems Association (URISA)[49] is a nonprofit association of professionals using GIS and other information technologies to solve challenges in state and local government agencies and departments. Numerous educational conferences and workshops are offered throughout the year. Their members can access their publications and past proceedings. Two URISA publications relevant to this PI are:
    - A GIS-specific Capability Maturity Model (CMM) that was developed by URISA in 2009 and was first implemented as a self-assessment tool by Washington State GIS operators. The results from this implementation were discussed at URISA's Annual Conference in 2010, and CMMs were subsequently adopted as an official URISA initiative [5].
    - The document titled "GIS Best Practices: Identification Development and Guidelines" has been finalized, and outlines a strategy for collecting, categorizing, developing, and maintaining practices related to the geospatial profession.
- Transportation Research Board standing committees with geospatial focus
    - AFB80 – Geospatial Data Acquisition Technologies in Design and Construction
    - ABJ60 – Geographic Information Science and Applications
    - ABJ95 – Visualization in Transportation

GIS Data Standards

A few state and local agencies have provided their GIS metadata standards and style sheets on their websites.

- The San Diego Regional GIS Council website[50] and the SanGIS website[51] have shared:
    - SanGIS Metadata Requirements
    - SanGIS Metadata Quick Reference Guide
    - SanGIS Metadata Cheat Sheet
    - Metadata FAQs
    - RGDW Publication Stylesheet Installation Instructions.docx
    - RGDW_Publication_1.4.cfg
    - RGDW_Publication_1.4.xsl
    - RGDW_Publication_1.4.xslt
    - MetadataEditorPaths.pdf (For quick reference when editing metadata)
    - MetadataEditorPaths.xml (For display in ArcCatalog. Save extensible markup language (XML) anywhere on your local machine)
- Utah DOT Road and Highway Schema[52]
- North Carolina DOT Metadata Content Standard for Geospatial Data[53]
- Oregon GIS (OGIC) Metadata Standard, Version 2.02, April 2015[54]

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[49] http://www.urisa.org/

[50] http://www.sdrgc.org/Documents/docs.html

[51] http://www.sangis.org/documents/policies.html

[52] https://gis.utah.gov/data/sgid-transportation/roads-system/

[53] https://xfer.services.ncdot.gov/gisdot/GISStandardsAndPractices/NCDOT%20GIS%20Metadata%20Content%20Standard.pdf

[54] https://www.oregon.gov/geo/standards/Oregon%20Geospatial%20Metadata%20Standard,%20v2.pdf

- Oregon Geospatial Enterprise Office website also listed OGIC-endorsed standards[55]
- Massachusetts Office of Geographic Information (MassGIS) standards[56]
- California Geospatial Framework Draft Data Plan[57] provides guidelines and data standards for various types of geospatial data
- Project Open Data Metadata Schema, Version 1.1,[58] provides naming conventions and required/optional fields. (CIO.gov is the website of the U.S. Chief Information Officer (CIO) and the Federal CIO Council)
- USGIN Metadata Content Recommendations website[59]

Federal Geographic Data Committee (FGDC) GIS Data and Metadata Standards

FGDC is an organized structure of federal geospatial professionals and constituents that provide executive, managerial, and advisory direction and oversight for geospatial decisions and initiatives across the federal government.[60]

FGDC has defined National Geospatial Data Asset (NGDA) datasets as "a geospatial dataset that has been designated by the FGDC Steering Committee and meets at least one of the following criteria: supports mission goals of multiple federal agencies, statutorily mandated, supports Presidential priorities as expressed by Executive Order, or by the Office of Management and Budget (OMB)." Each dataset is associated with a theme. Current themes are:

- Address
- Biodiversity and Ecosystems
- Cadastre*
- Climate and Weather
- Cultural Resources
- Elevation*
- Geodetic Control*
- Geology
- Governmental Units, and Administrative and Statistical Boundaries*
- Imagery*
- Land Use – Land Cover
- Real Property
- Soils
- Transportation*

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[55] http://www.oregon.gov/geo/Pages/standards.aspx

[56] http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/standards/

[57] https://www.fgdc.gov/grants/2005CAP/Reports2005/130-05-3-CA-FinalReport.pdf

[58] https://project-open-data.cio.gov/v1.1/schema/

[59] http://lab.usgin.org/profiles/doc/metadata-content-recommendations

[60] https://www.fgdc.gov/organization

- Utilities
- Water – Inland*
- Water – Oceans and Coasts*

Themes followed by an asterisk (*) are designated framework themes and are of critical importance to the NSDI. The Transportation theme standard provides a solid base for collaboration with federal partners and could be emulated for collaboration with local partners. Other theme standards can be emulated for similar Caltrans data sets.

Each theme is assigned to a federal lead agency to ensure maintenance of the theme data. The themes are support collaboration between federal agencies. The geoplatform.gov website contains plans and standards associated with this effort.

Metadata is information about data. Similar to a library catalog record, metadata records document the who, what, when, where, how, and why of a data resource.[61] Geospatial metadata describe maps, GIS files, imagery, and other location-based data resources. FGDC provides the follow basic metadata documents:

- Geospatial Metadata Fact Sheet
- Business Case for Metadata
- Value of Metadata (pdf, ppt)
- What is Metadata (pdf, ppt)
- Selecting a Geospatial Metadata Standard
- GeoPlatform/Data.gov Metadata Publication Guidelines (pdf)
- National Geospatial Data Asset (NGDA) Metadata Guidelines (pdf)
- Project Open Data (POD) Metadata Schema
- International Standards Organization (ISO) 191xx series of metadata standards
- Benefits of ISO
- FGDC-authored Content Standard for Digital Geospatial Metadata (CSDGM)
- FGDC-STD-010-2000 Utilities Data Content Standard Facilities Working Group Federal Geographic Data Committee June 200
- CSDGM (Content Standard for Digital Geospatial Metadata)[62] was developed for the documentation of GIS vector, raster, and point data.

The FGDC Steering Committee endorsed INCITS/ISO 19115-1:2014 Geographic information – Metadata – Part 1: Fundamentals and INCITS/ISO 19157:2013[2014] Geographic information – Data quality standards in December 2016.[63] The FGDC website[64] also provides links and a list of commonly used GIS-related standards. The FGDC website[65] also provides a list of all FGDC-endorsed standards including the following ISO 19xxx series standards:

- ISO 19103:2004 Geographic information – Conceptual schema language
- ISO 19104:2008 [2015] Geographic information – Terminology
- ISO 19107:2003 [R2013] Geographic Information – Spatial schema
- ISO 19108:2002 [R2013] Geographic information – Temporal characteristics
- ISO 19109:2005 Geographic information – Rules for application schema
- ISO 19110:2005 [R2015] Geographic information – Methodology for feature cataloguing

[61] https://www.fgdc.gov/metadata
[62] https://www.fgdc.gov/standards/projects/FGDC-standards-projects/metadata/base-metadata/v2_0698.pdf
[63] https://www.fgdc.gov/standards/news/fgdc-iso-metadata-standards
[64] https://www.fgdc.gov/resources/download-geospatial-standards
[65] https://www.fgdc.gov/standards/list

- ISO 19111:2007 [R2012] Geographic information – Spatial referencing by coordinates
- ISO 19112:2003 [R2014] Geographic information – Spatial referencing by geographic identifiers
- ISO 19115:2003 [2014] Geographic Information – Metadata
- ISO 19118:2005 [2006] Geographic information – Encoding
- ISO 19119:2005 [R2015] Geographic information – Services
- ISO 19123:2005[R2011] Geographic information – Schema for coverage geometry and functions ISO 19127:2005[2015] Geographic information – Geodetic codes and parameters
- ISO 19131:2007 Geographic information – Data product specifications
- ISO 19132:2007[R2013] Geographic information – Location-based services – Reference model
- ISO 19133:2005[R2011] Geographic information – Location-based services – Tracking and navigation
- ISO 19134:2007[R2012] Geographic information – Location-based services – Multimodal routing and navigation
- ISO 19135:2005[R2011] Geographic information – Procedures for item registration
- ISO 19136:2007 (R2015) Geographic information – Geography Markup Language (GML)
- ISO 19139:2007 [2015] Geographic information – Metadata – XML schema implementation
- ISO 19141:2008[R2013] Geographic information – Schema for moving features
- ISO 19144-1:2009 [R2015] Geographic information – Classification systems

ISO 19xxx Series Geographic Standards

ISO Technical Committee (TC) 211 creates standards about geographic information. The documents generated by TC 211 describe how to document spatial references, positioning services, quality evaluation procedures, and so forth. Documents are also identified by number. ISO standard documents are copyrighted by ISO, and must be purchased from ISO or the American National Standards Institute (ANSI).

ISO 19115 is a content standard that defines what information should exist in a metadata document. ISO 19139 produces an XML Schema defining how metadata conforming to ISO 19115 should be stored in XML format.[66,67]

Since the ISO 191** series of standards are endorsed by the FGDC, federal agencies are encouraged to transition to ISO metadata as their agencies become able to do so.[68]

- ISO 19115-1 was developed for the documentation of GIS vector and point data and geospatial data services such as web-mapping applications, data catalogs, and data modeling applications.
- ISO 19115-2 extension adds elements to describe imagery and gridded data as well as data collected using instruments, e.g. monitoring stations and measurement devices.
- ISO 19110 was developed to document feature catalogs (entity/attributes) and can be referenced or incorporated into a 19115-1 record.

[66] http://support.esri.com/technical-article/000006546
[67] https://trac.osgeo.org/geonetwork/wiki/115and139Confusion
[68] https://www.fgdc.gov/metadata/selecting-a-geospatial-metadata-standard

Nogueras-Iso et al. discussed various, commonly used GIS metadata standards and examples of ISO 19115 compatible metadata [6]. Longhorn et al. reviewed development of the ISO 19xxx series GIS metadata standards [7]. Bartha et al. provided the development history of the ISO 19xxx series of standards and a table listing all the ISO 19xxx series standards [8].

ISO 19xxx series standards implementation support

Guidelines and best practices in implementing ISO 19xxx series standards are available online from government agencies, OGC, and commercial GIS software makers, including:

- Australian New Zealand Land Information Council (ANZLIC) Metadata Profile Guidelines, Version 1.2, July 2011[69] which provides details on implementation of ISO 19115:2005 in New Zealand.
- Skenkler et al. describe the OGC's developmental efforts in adopting ISO 19115/19119 [9]. The OGC is a non-governmental group which promotes geospatial interoperability, specifically through the use of open-source GIS code and products.
- Stephen M. Richard and Wolfgang Grunberg wrote "Simple Metadata Recommendations for Geosciences Resources"[70] for the U.S. Geoscience Information Network (USGIN). This document provides guidance on the metadata content required to meet the use requirements for USGIN metadata, and thus reduces the daunting complexity of ISO metadata specifications to a manageable level.
- Use of ISO metadata specifications to describe geoscience information resources.[71]
- Infrastructure for Spatial Information in Europe (INSPIRE) Metadata Implementing Rules: Technical Guidelines based on ISO 19115 and ISO 19119.[72]
- Use of the ISO 19139 XML schema to describe Geoscience Information Resources, Version 1.1,[73] by Steven M. Richard and Wolfgang Grunberg, March 2010, Arizona Geological Survey.
- FGDC ISO Metadata Implementation Forum website[74] – the FGDC hosts a monthly webinar information series for the presentation and discussion of ISO implementation shared experiences, strategies, topics, and resources. The schedule and topics are listed below and the presentation slides and related resources are added to the website following each presentation. In addition, the FGDC hosted the 2017 ISO Metadata Summit.[75]
- Metadata Recommendations Supporting Data Discovery and Use in Data.gov and GeoPlatform.gov.[76]
- Environmental Systems Research Institute (ESRI) ArcGIS, Version 10.3, for Desktop support for ISO metadata standards.[77]

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69 www.anzlic.gov.au/sites/default/files/files/ANZLICmetadataProfileGuidelines_v1-2.pdf

70 https://my.usgs.gov/confluence/download/attachments/115179522/USGIN_MetadataRecommendationsGeoscienceResources_v1.03.pdf?version=1&modificationDate=1321809585585&api=v2

71 http://lab.usgin.org/sites/default/files/profile/file/u4/USGIN_ISO_Metadata_1.1.4.pdf

72 http://inspire.ec.europa.eu/documents/Metadata/MD_IR_and_ISO_20131029.pdf

73 http://repository.azgs.az.gov/sites/default/files/dlio/files/2010/u14/USGIN_ISO_Metadata_ofr-10-02_1.1.2.pdf

74 https://www.fgdc.gov/metadata/events/iso-geospatial-metadata-implementation-forum/index_html

75 https://www.fgdc.gov/metadata/events/iso-metadata-summit-2017/index_html

76 https://cms.geoplatform.gov/sites/default/files/document_library/GeospatialMetadataBestPractices_20141010.pdf

77 http://desktop.arcgis.com/en/arcmap/10.3/manage-data/metadata/support-for-iso-metadata-standards.htm

Integration of CAD and GIS Data

The following papers, books, reports, and websites provide computer-aided design (CAD) and GIS integration workflow and best practices:

- FHWA's "The Interoperability of Computer-Aided Design (CAD) and Geographic Information Systems (GIS) in Transportation: Case Studies of Select Transportation Agencies"[78] synthesizes case studies and supports GIS and CAD practitioners by providing examples of noteworthy practices of GIS-CAD interoperability solutions.
- AASHTO GIS for Transportation GIS-CAD Interoperability Round Table Discussion[79] contains notes collected during the round table discussion.
- Florida DOT CAD/GIS Interoperability presentation,[80] created by Rebecca Hatton, Geographic Mapping Specialist, Florida DOT Central Office, Tallahassee, Florida, summarized Florida DOT CAD to GIS integration effort.
- CAD/GIS Interoperability at KYTC (Kentucky Transportation Cabinet), presented by Jeremy Gould, KYTC Office of Information Technology,[81] provides workflow details of how KYTC integrates MicroStation CAD data with ArcGIS software.
- ESRI Suite (GIS) supports CAD data from MicroStation (.dgn) and Autodesk (.dwg) files.[82]
- ESRI's "Introduction to Using CAD Data in ArcGIS"[83] provides guidelines and workflow to integrate CAD to the ArcGIS GIS software currently used by Caltrans.
- ESRI's website[84,85] provides workflow and tutorials on CAD and GIS data integration.
- ESRI AcrGIS Resource Center: Their CAD Integration website[86] contains links to many CAD to GIS integration workflow articles.
- According to safe.com website,[87] the maker of Feature Manipulate Engineering (FME) software, FME supports the following CAD and GIS data formats: ArcGIS, MapInfo, GeoMedia, Smallworld, AutoCAD, MicroStation, and Intergraph.
- Zhen et al. documented detailed workflow using FME to convert CAD data to GIS data in an Institute of Electrical and Electronics Engineers' (IEEE) paper "Files' Conversion from CAD to GIS Using Spatial Data Conversion Tools Provided by FME" [10].
- Akinci and Karimi have written a book, *CAD and GIS Integration* [11], to provide readers with knowledge about existing and emerging methodologies, techniques, and technologies for integrating CAD and GIS.
- Autodesk, the maker of the Civil3D CAD software that is currently used by Caltrans, produced "Best Practices for Managing Geospatial Data,"[88] which provides best practices for integrating CAD data to GIS.

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78 https://www.gis.fhwa.dot.gov/documents/GIS_CAD_Report_Sept_2013.pdf
79 www.gis-t.org/files/KHu2N.pdf
80 http://www.fdot.gov/planning/statistics/symposium/2015/07_hatton.pdf
81 http://transportation.ky.gov/SASHTO/CADD%20and%20GIS%20Interoperability.pdf
82 http://desktop.arcgis.com/en/arcmap/10.3/manage-data/cad/showing-microstation-dgn-files.htm
83 http://proceedings.esri.com/library/userconf/proc15/tech-workshops/tw_361-127.pdf
84 http://desktop.arcgis.com/en/arcmap/10.3/manage-data/cad/what-is-cad-data.htm
85 http://desktop.arcgis.com/en/arcmap/10.3/manage-data/cad/an-overview-of-integrating-cad-data.htm
86 http://resources.arcgis.com/en/communities/cad-integration/
87 https://www.safe.com/solutions/for-data-types/cad-to-gis/
88 http://images.autodesk.com/adsk/files/best_practices_for_managing_geospatial_data1.pdf

Utilities Related Research and Resources

Surface and subsurface utility data will be integrated into GIS. The Transportation Research Board (TRB) has established the AFB70 Utilities Committee[89] to study the interrelationships between transportation systems and utilities including the accommodation of utilities in transportation corridors and rights of way. The American Society of Civil Engineers (ASCE) formed the Utility Engineering and Surveying Institute[90] (UESI) in October 2015 to generate products and services that promote and reward excellence in the engineering, planning, design, construction, operations, and asset management for utility infrastructure and engineering surveying.

Relevant ASCE, NCHRP, and FHWA reports on utility locations and highway systems include:

- NCHRP Synthesis Utility Location and Highway Design[91]
- SHRP 2 Renewal Projects – Early Identification of Utilities and Conflict Avoidance[92]
- ASCE 38-02 Standard Guideline for the. Collection and Depiction of Existing Subsurface Utility Data[93]
- UESI/ASCE XX-37 Standard for Recording and Exchanging Utility Infrastructure Data

Gaps in Findings

A comprehensive literature search failed to identify commonly shared GIS strategic plans and governance policies due to the diverse organizational nature of state government agencies. Many DOT and local agency GIS practitioners have posted their GIS strategic plans and governance policies on their website. Their GIS strategic plans and governance policies do share common elements and can be used as guide for Caltrans GIS implementation.

The ISO 19xxx series standard is complex and not easily understood. However, peer-to-peer support is available from other DOTs, ASHTO, and FHWA. ESRI has development software to support ISO 19xxx series standard implementation. However, Caltrans has to develop its own workflow and best practices on ISO 19xxx standards implementation that would work for its internal data providers.

Approximately 23 questionnaires were sent out to geospatial experts in state DOTS and other organizations. Only five responses were received, as presented below. A follow-up survey including some means to encourage response is recommended.

Next Steps

Strategic Steps for GIS Implementation

1. Review DOTs and other public agencies GIS Strategic Plan documents.
2. Develop a Caltrans GIS Strategic Plan based on Caltrans Geospatial Strategic Direction.
    a. Create Caltrans' own GIS governance policy.
    b. Seek support from, and adoption by, Caltrans division chiefs.

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[89] https://sites.google.com/site/trbcommitteeafb70/
[90] http://www.asce.org/utility-engineering-and-surveying/utility-engineering-and-surveying-institute/
[91] http://www.trb.org/resource.ashx?sn=nchrpsyn405
[92] http://www.fhwa.dot.gov/goshrp2/Solutions/Renewal/R01A_R01B_R15B/Utility_Bundle
[93] http://ascelibrary.org/doi/book/10.1061/9780784406458

c. Caltrans GIS Strategic plan is vital in seeking resources for GIS implementation and support from internal GIS data providers, as well as defining the roles and responsibilities for the Division of Research, Innovation, and System Information (DRISI) and other divisions and offices internal to Caltrans.

3. Develop a GIS Implementation Plan.
    a. Develop easy to understand data standards that are compatible with ISO 19xxx series standards.
    b. Adopt ISO 19xxx series standards.
    c. Develop best practices documentation for various GIS data (CAD, asset, utilities, roads, etc.).
    d. Establish a technical GIS committee to address technical GIS implementation issues such as software tools, users, and data providers training and education.
    e. Attend GIS meetings and webinars hosted by AASHTO and FHWA to gather and learn latest best practices from other DOTs.
    f. Teach and communicate with GIS stakeholders (IT, data providers, and data consumers).

ISO 19xxx Series Standards Implementation

1. Create a primer for ISO 19xxx series standards so that internal data providers can understand and provide the required metadata without spending a large amount of time to read and interpret the ISO 19xxx series standard themselves. Simply listing the ISO standards that internal data providers have to comply with is not enough to encourage data providers to adopt and consistently implement the ISO 19xxx series standards throughout the twelve Caltrans districts.
2. Attend GIS meetings and webinars hosted by AASHTO and FHWA to gather and learn latest best practices from other DOTs.
3. The Caltrans library has ISO metadata standards documents. Caltrans DRISI should purchase any remaining volumes to complete its ISO 19xxx standards documentation.
4. Teach and communicate with data providers about ISO 19xxx standards.
    a. Provide best practices and workflow documentations on ISO 19xxx standards implementation.
    b. Help data providers in using available software tool and workflow to comply with data standards.

CAD and GIS Integration

1. Software tools to convert CAD files to GIS data are available from ESRI,[94] Safe Software's FME,[95] Bentley's MicroStation,[96] and Autodesk's Civil3D.[97] However, Caltrans has to develop a set of workflows to ensure consistent application of these conversion tools by the internal data providers at the different Caltrans districts.

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[94] http://www.esri.com/
[95] https://www.safe.com/
[96] https://www.bentley.com/en/products/brands/microstation
[97] https://www.autodesk.com/products/autocad-civil-3d/overview

Detailed Findings

Consultation with State DOTs and Other State Agencies

A survey of other transportation and local agencies' current GIS Standards and Technology Implementation was conducted. This survey was sent by AHMCT to a contact list (see Contacts section below) provided by Caltrans. The questionnaire is provided here for reference and the questions are omitted in the results section.

1. Respondent's (your) name, job title, and organization
   Name:
   Job title:
   Organization:
   Email:
   Phone Number:
2. Does your organization have a GIS data governance and stewardship policy based on best practices for effective statewide transportation GIS data standards that can be shared with Caltrans? If yes, please provide link or document attachment in the email.
3. Does your organization have any standards and best practices for data collaboration between internal geospatial data providers/owners (this would include standards for database software and schema)? If yes, please provide link or document attachment in the email.
4. What are your organization's GIS metadata standards? This may include:
   a. Metadata format (e.g., ISO 19139, ISO 19115, Federal Geographic Data Committee (FGDC) metadata standard)
   b. Mandatory metadata
   c. Optional metadata
   d. Naming conventions

   If possible, please provide link or document attachment in the email.
5. Does your organization have any policies, guidelines, or best practices on when data should be open / public, available on-request, or confidential / internal? If yes, please provide link or document attachment in the email.
6. Specific to GIS/CAD integration:
   a. Has your agency utilized or considered using GIS data for design purposes, public meetings related to projects, or other project delivery tasks? If yes, please briefly describe how.
   b. Has your agency considered or performed incorporation of Computer-Aided Design (CAD) and survey data into GIS (e.g., asset management, project prioritization, performance dashboards)? If yes, please briefly describe how.
7. Please provide any other information, documents, or feedback that you believe may be of value for this research. If you feel your agency has more information to offer on this subject, please provide contact information to allow a follow-up discussion.

The below questionnaire responses were received.

Colorado

Gary Aucott
GIS Support Unit Manager
Colorado DOT
303-512-4444, gary.aucott@state.co.us

Survey answers:

2. No, CDOT does not have this as a policy. We would be interested to know what the main elements of such a policy would be, in order to craft a future policy for CDOT.
3. UTM Zone 13 projection (typically)
   If data lies on our linear referencing system we have standard schema fields for ROUTE, REFPT, ENDREFPT.
4. We tend to use the ESRI ArcGIS Metadata format and FGDC. We do not have any formal naming conventions.
5. This is typically done on a case by case basis. Bridge/structure data requests get approved by Staff Bridge. Some environmental data is internal only. Some ITS data is restricted. Some crash/fatality data is restricted.
6. a. We make GIS data available to CAD users for titlesheets and design purposes as they see fit. We have been using GIS data and web maps for public outreach and commenting on projects.
   b. We have a method to convert CAD data to GIS in a relatively easy way if the CAD file has the necessary coordinate information. (This is a very small subset of CAD files at this point.) However, our process is not mature and we are not currently making much us of CAD to incorporate into GIS yet. The one exception is for our right of way data. We are working with AppGeo to convert CAD and other survey data/documents into GIS to model our ROW boundaries and related projects/parcels.
7. N/A

Minnesota

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Data Systems & Coordination Section Director
Minnesota DOT
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Ruth Betcher
Minnesota DOT
ruth.betcher@state.mn.us

Survey answers:

2. http://tomcat7prod24:8080/wiki/jsp/Wiki?action=action_view_attachment&attachment=MnDOT+GIS+Strategic+Plan.docx
3. See #2
4. http://www.mngeo.state.mn.us/committee/standards/mgmg/metadata.htm
5. Department is working on a revision now. Heading towards all data is public and should be freely shared unless specifically identified otherwise. To restrict it usually requires that: the data is personal information; part of current legal action; or restricted by licensing.
6. a. District Wide PLS Maintenance .pdf: Shows section corners that require setting after a project is completed.
   b. D6 Surveys Database Examples.pdf: D6 surveys Database used to help track section corner work completed and right-of-way

7. N/A

Attached files:
1. Condemnation Exhibits - 1986 Aerial.pdf: Old air photos georectified to aid in condemnation proceedings.
2. Conveyance Negotiation - S.P. 8508-000.pdf: Conveyance notification site.
3. Design Survey Request (After) - S.P. 6607-49.pdf: Survey request map made for the field crew.
4. Permits Dept. Custom Maps.pdf: Permit map with right-of-way map georectified showing encroachment into right-of-way.
5. Spring Flight Targeting - 16s-45_5080_5580.pdf: Spring flight targeting including property owner names.
6. Visual Aide - Title Issues - S.P. 2319-16.pdf: Visual aid for property with contours.

North Dakota

Gerald Kautzman
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North Dakota DOT
(701) 328-3558, gkautzma@nd.gov

Survey answers:

2. No
3. No
4. At this time we have not adopted standards
5. No
6. a. No
   b. We currently have a very small staff of people who are responsible for GIS in the NDDOT we have not fully developed our standards for data creation or metadata.
7. We currently have a very small staff of people who are responsible for GIS in the NDDOT we have not fully developed our standards for data creation or metadata.

Attached files: None

Virginia

Geraldine S. Jones
Planning Specialist
Virginia DOT
804-786-7459, Geraldine.Jones@VDOT.virginia.gov

Survey answers:

2. VDOT has an internal ArcGIS Server application/SDE database that contains over 300 GIS layers that have internal and external sources. The following is the standard naming convention for the SDE layers: GIS_DATA.SDE_Source_Name (example: GIS_DATA.SDE_VDOT_Roads). Data is updated on a regular schedule and follows an agency standard QA/QC process.
   In the past few years, VDOT has moved toward ArcGIS Online to share and present VDOT data and applications. Each data owner is responsible for content. Roles are administered to secure content. The role of Publisher_VDOT+ within the VDOT ArcGIS Online organization is used to create and maintain content. A Publisher_VDOT, you will only be able to share content to the organization.
   How to Create a view/edit application – VDOT ArcGIS Online Implementation Guide Series:

https://vdot.maps.arcgis.com/apps/Cascade/index.html?appid=84c75208e15e49e48ca2a05410996c7f

3. Yes
   DOT ArcGIS Online Implementation Guide Series:
   https://vdot.maps.arcgis.com/apps/Cascade/index.html?appid=84c75208e15e49e48ca2a05410996c7f
4. VDOT follows FGDC metadata standards required by VGIN (Virginia Geographic Information Network) - https://www.fgdc.gov/
   VGIN (Virginia Geographic Information Network) was established in 1997 in Virginia Code to "foster the creative utilization of geographic information and oversee the development of a catalog of GIS data available in the Commonwealth." Some of the core functions of VGIN are:
   - Develop & recommend policies & guidelines required to support state and local government exchange, acquisition, storage, use, sharing and distribution of geographic or base map data and related technologies
   - Compile a data catalog consisting of descriptions of GIS coverages maintained by individual state and local government agencies
   - Setting priorities for the development of state digital geographic data and base maps that meet the needs of state agencies, institutions of higher education, and local governments
   - Provide services, geographic data products, and access to the repository at rates established by the Division

   Source: Virginia Code § 2.2-2026 and § 2.2-2027
   https://www.vita.virginia.gov
5. For the most part VDOT has open data that accessible through the agencies external site and AGOL.
   - Outside VDOT: https://outsidevdot.cov.virginia.gov
   - Virginia Roads: http://www.virginiaroads.org/
   - AGOL: http://vdot.maps.arcgis.com

   Under the Freedom of Information Act (FOIA) data is available upon request - http://foiacouncil.dls.virginia.gov/ref/GIS_Records.pdf. However there are exceptions. These FOIA exemptions mostly concern sensitive environmental resources including threatened & endangered species and archaeological sites. In these cases, VDOT has data sharing agreements with the data providers. Permission based access is used to protect sensitive data.
6. a.
   Yes, VDOT uses GIS data for project planning, development, implementation, and maintenance.
   - Project Planning
     - VDOT has the Smart Scale model in place, which includes spatial components to evaluate and rank proposed projects to determine eligibility and funding. These spatial data components include: linear referencing system (roads), planning, socio-economic, and environmental. http://vasmartscale.org/
   - Project Design
     - Example: LIDAR data is being used to design sound walls.
     - Future 3D modeling and design.
   - Project Development
     - GIS data is used to evaluate projects for NEPA.

        - Determine potential environmental impacts including: T&E species, cultural resources, and wetlands.
    - GIS data is used to determine inner agency coordination and create maps necessary for permit acquisition.
    - GIS data is used to make presentation quality maps used at public meetings.
- Maintenance
    - GIS data is used to keep an evaluate and inventory maintenance needs
        - Example: Paving Status: scheduled, in progress, completed, deferred

b.
VDOT is looking towards combining CAD and GIS for project prioritization (Smart Scale). VDOT like to use 3D models to improve communication with the public, especially in the planning phase.

7. https://outsidevdot.cov.virginia.gov/Z0CQ9/SitePages/Home.aspx
http://www.virginiaroads.org/
http://www.arcgis.com/home/search.html?q=vdot&t=content&start=1&sortOrder=desc&sortField=relevance&focus=applications
https://vdot.maps.arcgis.com/home/index.html
http://vdot.maps.arcgis.com/apps/MapAndAppGallery/index.html?appid=681f2c36314d42d7911a97a063ea23a5

Attached files: None

Washington

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Survey answers:

2. We do have statewide Office of the Chief Information Officer (OCIO) and agency data management policies. The OCIO policies cover IT Data Security Standards, Open Data, and specific GIS data standards regarding metadata and standard projections. WSDOT also has a standard GIS Data Publication Procedure. The agency's data management policies cover data stewardship as well as data governance via the Enterprise Information Governance Council. We try to maintain a standard schema between all similar data regardless of format.
3. We do have statewide Office of the Chief Information Officer (OCIO) and agency data management policies. The OCIO policies cover IT Data Security Standards, Open Data, and specific GIS data standards regarding metadata and standard projections. WSDOT also has a standard GIS Data Publication Procedure. The agency's data management policies cover data stewardship as well as data governance via the Enterprise Information Governance Council. We try to maintain a standard schema between all similar data regardless of format.
4. a. We use FGDC format, as per the statewide OCIO Standard.
b. Mandatory definitions exist for all data elements centrally managed via WSDOT IT Division's Data Management Services, including GIS. If we use SQL Server's native spatial capabilities to store spatial data, we create two tables (SpatialReferenceSys and GeometryColumns) to house spatial reference and spatial reference authority and geometry type. We house regularly used data (spatial or non) in the WSDOT Data

Library to provide master data to WSDOT's application systems. Metadata must be provided for all enterprise and externally published GIS data.
c.
d. Camel case with no underscores. Less than 32 characters. Varies by Object Type (database vs table vs field name, for instance). Databases are named by <Subject><Subset><YearMoDa>. We have a standard abbreviation resource that is used in naming conventions. We are also developing a taxonomy for the agency's data that we will incorporate to aid searching and finding desired information. http://www.wsdot.wa.gov/mapsdata/geodatacatalog/maps/NOSCALE/DOT_TDO/LRS/24kLRS.htm

5. Yes, we do and they are enclosed. We track data categorization as per the statewide OCIO standards in WSDOT's Data or Terms Search (DOTS). These categorization standards control whether or not the data can be made publicly available, and if not, what special access requirements are needed.
6. a. Yes, we have a project underway to utilize ProjectWise's GIS Connector to integrate GIS and CAD data. We do actively use GIS for public meetings related to projects, project scoping, and for environmental assessments. The ArcGIS Online Community Planning Portal allows local agencies to collaborate with WSDOT on project planning. We have a Corridor Sketch project underway as well to help enhance planning activities.
   b. Yes, for Stormwater Inventory and Permitting and the Highway Activity Tracking System and also for the development of state route linear referencing system. Standardized CAD formats (levels and colors, etc.) and provision is very helpful to making sure that integration can occur seamlessly.
7. Standardizing on the underlying database for all systems (SQL Server and ESRI) is very helpful to integration activities, as is keeping current and consistent on software versions.

Attached files:
Capability Model for Publishing Open Data.docx
IT Manual 40001 WSDOT Data Management Standard Practice_Final.pdf
Open Data Plan-WSDOT.DOCX
Secretary's Executive Order 1037.pdf
Secretary's Executive Order 1095.pdf
WSDOTOnlineMapCenterUserGuide.pdf

Contacts

AHMCT contacted the individuals below to gather information for this investigation.

State Agencies

California

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References

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2. "Geospatial Information Infrastructure for Transportation Organizations," Transportation Research Board
3. "GIS Strategic Plan for the U.S. Department of Transportation Version 1.0 2016-2019," 2016. https://www.transportation.gov/sites/dot.gov/files/docs/GISStrategicPlan_0831_final.pdf
4. J.P. Hall, *Successful Practices in GIS-Based Asset Management*, 2015.
5. "GIS Capability Maturity Model Peer Exchange," 2016. https://www.gis.fhwa.dot.gov/documents/Capability_Maturity_Model_Peer_Exchange.pdf
6. J. Nogueras-Iso, F.J. Zarazaga-Soria, J. Lacasta, R. Béjar, and P.R. Muro-Medrano, "Metadata Standard Interoperability: Application in the Geographic Information Domain," *Computers, Environment and Urban Systems*, **28**(6): pp. 611-634, 2004.
7. R.A. Longhorn, "Geospatial Standards, Interoperability, Metadata Semantics and Spatial Data Infrastructure," in *NIEeS Workshop on Activating Metadata, Cambridge, UK, 23pp*, 2005.
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